The Private LTE Opportunity for Industrial and Commercial IoT

Wireless networking in the industrial domain is a large, untapped growth opportunity for smart connected systems. It will enable the transition from disparate disconnected networks to smart systems that become "portals" into a whole new world of customer value-creation. A new generation of wireless technology—Private LTE networks—is unleashing an age of pervasive connectivity and awareness that is fostering entirely new and more efficient modes of customer interaction and service delivery.

smart systems design | Harbor Research

The term “wireless networking” implies universal connectivity, but we have yet to see that in today’s industrial and business critical domains like manufacturing, supply chain, transportation systems and energy. Instead, we see a fragmented landscape full of proprietary device networks, cautious users and buyers, and broken promises about the potential of wireless technologies. Amid all this noise and clutter, a new generation of wireless communications developed for challenging environments has emerged. Private LTE networking technology—LTE-based wireless technology for local and independent networks—enables users and customers to integrate diverse sensors, machines, people, vehicles and more across a wide range of applications and usage scenarios. It treats user concerns—from reliability and service quality, to security and compliance—as challenges that can be addressed by a single, scalable wireless networking solution that leverages LTE’s technology and ecosystem benefits. In taking this perspective, private LTE networks are jumping ahead of the current market confusion about wireless connectivity and is re-defining how value is created from devices and data. Key solutions for this new breed of private LTE network are LTE-based solutions using the U.S. specific CBRS 3.5 GHz band, MulteFire™ for global unlicensed spectrum like 5 GHz or dedicated licensed spectrum.

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EXHIBITS

THE INTERNET OF THINGS IS REALLY HERE...

Pervasive Connectivity

The propagation of connectivity across virtually any electronic device network, enabling IP-based computing and data communication.

The race to pervasive connectivity is rapidly changing the milieu of our times. Networking improves the value of a product, through the potential of economic activity from integrating, analyzing, and acting on data. Devices will blend into every venue, and vast opportunities will arise for companies delivering, managing and responding to the rich media and data being generated.

Smart devices will enable new services such as status monitoring, usage tracking, consumable replenishment, automated repair, and new modes of interaction whose value together could reach beyond $500 billion in value-added revenues by 2017 (source: Harbor Research smart systems forecast).

As Moore's law persists and the price of integrating intelligence and connectivity into products continues to fall, networked devices will push further and further into the mainstream. This process is a virtuous cycle with lower prices driven by higher quantities, and vice versa, making intelligent devices increasingly prevalent in our lives and businesses.

With the rapid growth of wireless networks—from cellular to Wi-Fi to sensor nets—connecting these devices to the Internet has never been easier. The growth of devices on the Internet today occurs in two distinct ways. The first is that networks designed for custom applications—such as video, voice, cellular, etc.,—are all migrating toward integrated IP-based networks. This trend requires the Internet to absorb wholesale transitions of full-scale networks into its existing framework.

Private LTE Network

A local LTE network that is utilizing dedicated radio equipment to service a premise with specific IoT applications and services. The use of dedicated equipment allows it to be independent of traffic fluctuation in the wide-area macro network. By focusing on specific IoT applications and services, the private LTE network can be tailored for more optimized performance such as low latency. A Private LTE network can be deployed in shared and unlicensed spectrum, as well as locally dedicated licsensed spectrum, e.g. CBRS Priority Access License (PAL).

At the same time, new classes of devices are becoming network-enabled, not just laptops and cellphones. Today, virtually all products that use electricity —from toys and coffee makers to cars and medical diagnostic machines— possess enormous potential that can only be harnessed by the power of Internet connectivity and the data processing capability of the network. Private LTE is a new approach to networking technology that can serve operationally-intensive device environments, propagating connectivity to support optimized IoT systems.

INDUSTRIAL and BUSINESS CRITICAL APPLICATIONS ARE BIG OPPORTUNITIES

Most industrial and business critical market segments are undergoing dramatic change. But, more importantly, these environments have tended to keep investments in direct process innovation and automation relatively higher than in other areas.

While we all might think that wireless is everywhere that is not the case for industrial and related business critical market applications. These markets are highly fragmented and competitive with users and customers who are conservative adopters of new technologies, driven by return on investment

(including associated costs). The benefits of IP-based wireless networking have become much clearer, and this, combined with an increasing number of industry-specific standards, have accelerated the pace of adoption.

Industrial and related business critical market segments include diverse resource-based industries, manufacturing, and infrastructure-driven segments covering a wide range of domains, including:

» Resource-based segments including mining and oil/gas exploration and delivery;

» Manufacturing-based segments including chemicals, pharmaceuticals, consumer goods, automotive, aerospace and electronics;

» Power generation, transmission and distribution;

» Transportation venues such as airports and railway stations;

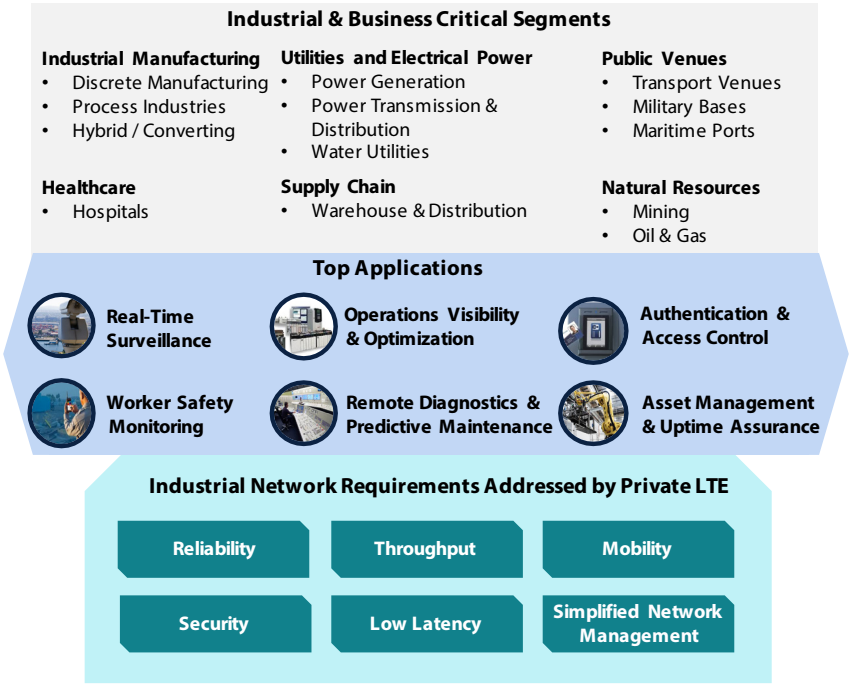
» Healthcare delivery; and,

» Supply chain including warehouses, distribution and container facilities.

Business Critical Markets

Business critical markets are commercial B2B segments that are operationally intensive. An activity, device, service or system whose failure or disruption will cause a severe failure in business operations. As a result, operationally-intensive markets require network characteristics including low latency, high reliability and high security.

Exhibit 1: Private LTE Segments, Applications and Requirements



There is a wide range of players that supply machines and equipment, those that integrate them into operations as well as the end use companies that utilize these machines to run their operations.

Wireless Technology In Business Critical Apps

Wireless networking in industrial and business critical segments and applications is reaching a tipping point for growth:

- *Overall the Internet of Things (IoT) market has four main network platforms that need to be addressed—WPAN, WLAN, WWAN and Wireline.*
- *Wireless connectivity overall is forecast to comprise over 80% of the intelligent device connectivity market by 2020; wireless sensor networks are essential for the success of the IoT.*
- *The wireless IoT opportunity in industrial and business critical segments could grow to over 750M connected devices.*

While progress has been made to leverage digital, Internet of Things and smart systems technologies, there is still a need to improve the performance of certain technologies, such as wireless networks, for these to be embraced and integrated into customer operations. Ultimately, adoption of smart connected systems utilizing next generation wireless technologies is no longer a "luxury." These types of solutions are increasingly needed to meet the growing demands of the very competitive arenas that comprise industrial and business critical markets. Private LTE networks will set the stage for a new chapter in the role of network intelligence in business critical systems, but before delving into the new thinking that makes this story possible, let's talk about why it's necessary at all.

CUSTOMER REQUIREMENTS WILL DRIVE ADOPTION

We have now entered the age when diverse devices will communicate with, and control, other objects over a global data network—24/7/365. It is vitally important that business leaders understand the effects of pervasive connectivity on their business, and what they might do right now to position themselves for opportunities that are literally just around the corner. A few of the myriad examples of potential solutions include:

- Manufacturing equipment, hoist cranes in shipping ports, and vehicles that can predict when and why they are likely to fail, and then alert you or your service organization before the failure occurs—or even, in some cases, fix themselves.
- Buildings and manufacturing facilities with "digital nervous systems" that ensure occupant comfort and safety, lower energy and operating costs and even enhance productivity.
- Supply chains and physical distribution systems that know exactly where every piece of inventory is at any moment, and under what conditions it arrived.
- Industrial customers who can save money on energy by being able to see, in real time, exactly how they're using it.
- Original Equipment Manufacturers that are not "disintermediated" at the point of sale, but stay connected to end-customers via a steady stream of status/usage/performance data.
- Healthcare facilities where accurate, up-to-the-minute patient information is always available because every piece of equipment, from digital thermometers to life-support machines, is networked and associated with a patient ID and health delivery professionals.

Visions of wireless sensors, robots, conveyors, fork lifts, etc. have been in abundant supply for several years now. Deployment, however, has been slower than expected due to a wide range of technical constraints, cautious buyers and support limitations that have inhibited integrating devices in business critical operations at the edge of networks—what we like to call the "last inch" of intelligent device integration. Furthermore, as more devices come online, the inefficient use of spectrum is choking the breadth of viable options for operators to achieve this "last inch" of IoT networking.

Existing technology has proven cumbersome and costly to apply with many conflicting protocols, incomplete component-based solutions and poor support.

We believe some basic design principles must be put in place to guide the development of wireless connected sensors and devices designed for business critical markets. Realization of wireless network value demands that we design not only sensors and networks, but also data management of sensor inputs in ways not well addressed by current technologies.

Many nascent IoT networks are Wi-Fi, Bluetooth or Zigbee/WirelessHART based. While this will suffice for certain enterprise applications, expanded network capabilities are required for integrating connectivity into industrial and related business critical applications.

The Private LTE Addressable Opportunity is Significant

Private LTE deployed in Industrial and Business critical markets is expected to generate nearly $70 billion in estimated Smart Systems revenue by 2023. This $70 billion opportunity will be driven by the enablement of over 760 million device shipments by the end of the forecast period.

NEW WIRELESS CAPABILITIES REQUIRED - ENTER PRIVATE LTE

The tools we are working with today to put sensors on networks were not designed to handle the diversity of devices growing from miniaturization of electronics, the scope of new capabilities, the need to carefully manage power requirements, and the massive volume of data-points generated from device interactions. These challenges are diluting the ability of technical organizations to efficiently and effectively manage application development.

The Internet of Things, in many ways, presupposes the existence of a zero-infrastructure, ad-hoc network that makes seamless peer-to-peer physical connections possible. Obviously, billions of devices of wildly varying types cannot each receive individual attention and configuration by humans, or conform to elaborate prior specifications. If it literally takes a trained network engineer to install a smart light bulb, the Internet of Things is never going to work—users must be able to do this without even realizing there is a network there at all.

Many schemes and 'standards' for device connectivity already exist. But of course, all those 'solutions' add up to one big problem. Users can't manage countless standards to drive value generation; they want fewer, more versatile networks (whether NFC/BT, LAN or WAN) to support diverse device networks. In the end, they just want it all to work seamlessly and therein lies the challenge—networks of this scale and this application diversity have never been successfully assembled before.

Private LTE Impact on Network Performance

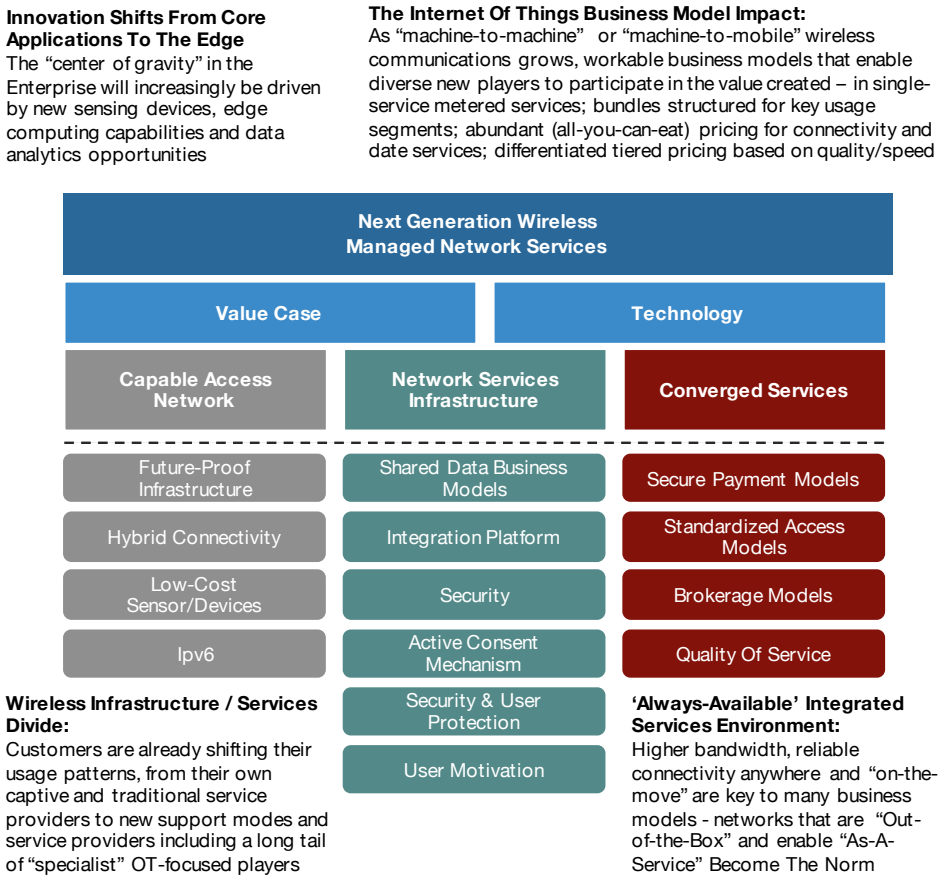
Private LTE can improve critical network capabilities including well-characterized performance measures such as low latency, high reliability, consistent performance in the presence of well-known interference sources, high security, longer range, high capacity, interoperability between suppliers, high throughput and high mobility.

Citizens Broadband Radio Service

The CBRS Alliance was assembled following the Federal Communications Commission's (FCC) ruling that established the shared commercial use of the 3.5 GHz band with incumbent military and fixed satellite stations in the United States called Citizens Broadband Radio Service (CBRS). As part of the CBRS plan, a three-tiered system was established to dictate and coordinate spectrum access. The tiers are as follows: Incumbent, Priority Access License (PAL) and General Authorized Access (GAA) users.

We are reaching a critical juncture in market development where engineering organizations will soon implore for a completely new approach—one where the network system and its components can be utilized again and again across an ever-broader range of devices, applications and business processes. This paper seeks to highlight a networking solution that sits at this critical juncture—private LTE. Private LTE is an important new wireless networking platform offering from people who are thinking about the scope and on the scale that sensors, machines and other related physical real world operations systems deserves.

Exhibit 2: Confluence of Forces Creates Next Gen Industrial Wireless Opportunity



The CBRS Alliance and the MulteFire Alliance are collaborative ecosystems —working on multiple new use cases—including the simplification of private LTE network deployments. These technology initiatives bring key capabilities around spectrum sharing, network technology coexistence and simplified deployments that can drive private LTE networks towards a prominent role in IoT network infrastructure. CBRS as a technology-neutral, spectrum sharing framework, may bring a radical shift in the spectrum and network services market that allows users to easily deploy a private LTE network in the U.S. shared 3.5 GHz spectrum. MulteFire can be deployed in the unlicensed 5 GHz

bands (see MulteFire.org for additional spectrum band supported), creating an unprecedented opportunity for LTE technology to support operational networks that have historically been dominated by wired networks, specialized short-range wireless or Wi-Fi. While LTE deployments in the 3.5 GHz CBRS band are limited to the U.S., MulteFire will support deployments in the 5 GHz unlicensed band worldwide. The unique architecture and spectrum access of CBRS and the standalone unlicensed operation of MulteFire create a simple way to deploy flexible LTE network infrastructure in a closed, private mode. It should be noted that dedicated licensed spectrum can also be used for private LTE networks, e.g., by partnering with a mobile network operator.

MulteFire

The MulteFire Alliance was founded to develop a network technology that brings LTE performance and Wi-Fi simplicity into a single solution on a global scale. MulteFire technology is based on 3GPP Licensed Assisted Access (LAA), which combines licensed and unlicensed spectrum while sharing spectrum fairly with Wi-Fi. Using the same listen-before-talk method as LAA and Wi-Fi, MulteFire coexists with LAA, Wi-Fi and other technologies.

Private LTE operation in shared and unlicensed spectrum allows operators access to spectrum without having to invest in expensive licenses. These cost savings associated with deploying a network with high operational efficiency and high reliability are attractive for industrial and business critical segments seeking to improve the bottom line. These new spectrum sharing technologies combined with the capabilities of private LTE will drive operational efficiencies in terms of both cost and performance.

The MulteFire Alliance and the CBRS Alliance understand that the tools we are working with today to integrate wireless devices and to analyze sensor data were not designed to really address the deployment, integration and operational challenges associated with industrial and business critical environments. For instance, with private LTE, network managers have the ability to optimize performance to get predictable latency and improved quality of service, supporting operational efficiencies across the board. These improvements to network performance that translate into greater operational efficiencies will drive a much-needed network design overhaul across operationally intensive environments.

The developers of private LTE understand that customers in business critical market environments expect evolving network and integration tools to be functional, ubiquitous, and easy-to-use. Within this construct, however, the first two expectations run counter to the third. In order to achieve all three, a new approach is required—a unified wireless platform for smart systems and devices combined with development tools that work together seamlessly, securely and safely across diverse applications and a network architecture that is truly scalable.

PRIVATE LTE DRIVES COMPELLING NEW APPLICATIONS and USE CASES

To date, remote services and IoT deployments have largely been focused on simple remote diagnostics, tracking and location services, in large part because of technical complexities and business model challenges.

The challenges of developing applications and integrating diverse devices onto networks in an interoperable manner have been facing big adoption hurdles. The

Private LTE Case Study: Transforming the Racing Experience

In preliminary trials of Private LTE technology of CBRS spectrum, Qualcomm, Alphabet Access Group and Nokia illustrated the capacity and reliability for 360 degree video streaming from within a high-speed vehicle. The key features exemplified in this use case, including capacity and reliability extend into the requirements for industrial and business-critical networks.

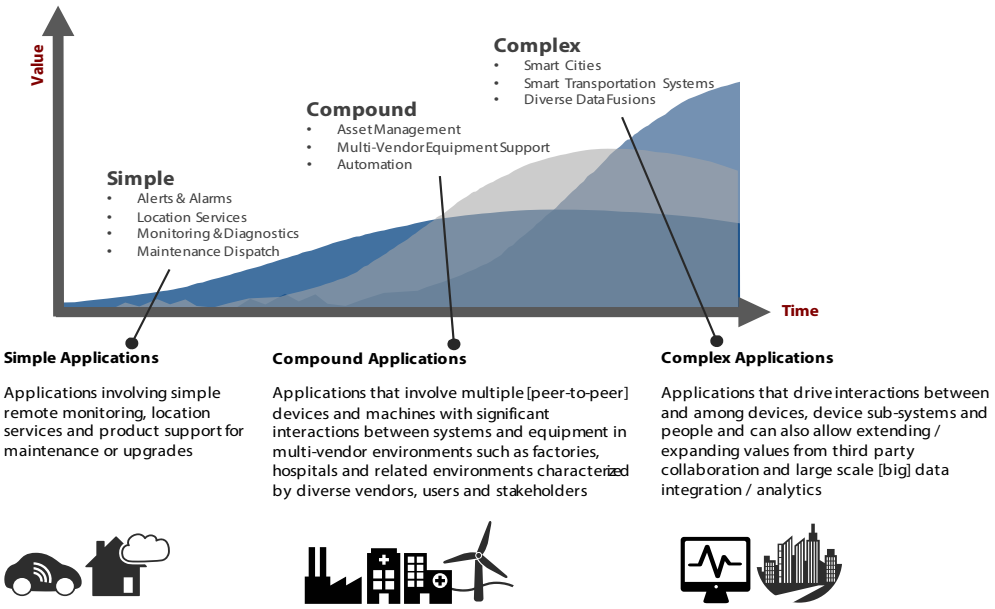
inability of today's popular enterprise IT systems to interoperate with distributed heterogeneous device environments is an obstacle that we are finally starting to overcome and one that private LTE will help alleviate.

As technologies mature and open standards become the norm, applications based on deeper interactions among devices, systems and people will drive more compound and dynamic value streams. This opens new collaborative business model opportunities that have the potential to drive much greater value for the customer.

Robust connectivity allows for a complete ecosystem of machine and operational data, creating the ability to engage in collaborative business models. Facilitating an unbroken circle of data and information value based on the integration of people, processes, and relationships across the complex ecosystem partners is the "holy grail" of smart systems. As such, private LTE networks should be viewed as a mechanism by which companies connect devices and gather and leverage more data, more efficiently. This allows companies to move across this business model spectrum, enabling simple to complex applications and filling the gaps that exist in the interactions of data within and across business critical machine and human processes.

In each of the top industrial and business critical market segments, these applications will act as entry points to increasingly support operationally intensive wireless applications. Control and fixed machine applications will continue to leverage wired networks with wireless technology supporting ancillary data services providing greater visibility into machine performance and improve overall system intelligence.

Exhibit 3: Private LTE Can Catalyze the Evolution of Application Complexity



The following illustrative case studies show the ways in which private LTE will address current market challenges, improve existing systems and drive value creation with flexible, highly reliable and secure wireless networks.

Mining Case Study

Mining Private LTE Market 2023 Opportunity

20.2 million shipments

$5.5 billion in Private LTE Addressable Smart Systems Revenue

» **Challenge:** commodity market volatility is continually putting pressure on mining companies to achieve greater operational efficiencies to meet tighter margins and ensure a larger bottom line. This capital-intensive market is undergoing significant adoption of networked equipment to support automation, remote monitoring and predictive maintenance applications.

» **Solution:** particularly in remote areas where IP access is limited, a dedicated LTE network will provide the throughput, latency, reliability, coverage, and mobility requirements of critical mining operations while ensuring high security as the convergence of information and operational technologies (IT and OT) bring greater susceptibility to cyber attacks.

» **Impact:** a dedicated LTE network will provide the network infrastructure for automation applications to achieve greater safety and efficiency metrics of mining operations. Furthermore, with increasing cybersecurity threats to mining industries, a private LTE network will isolate threat actors over public or macro networks.

Shipping Port Case Study

Shipping Port Private LTE Market 2023 Opportunity

22.8 million shipments

$2.4 billion in Private LTE Addressable Smart Systems Revenue

» **Challenge:** increasing container traffic is overwhelming port operators, ultimately congesting distribution and straining asset health.

» **Solution:** a private LTE network could support the secure automation of mobile equipment within the port while also supporting wireless IP security, computer vision applications such as optical character recognition (OCR) and remote monitoring of capital intensive port equipment (STS cranes, tractors and trucks).

» **Impact:** a single, integrated wireless network that could support automation, security and remote monitoring functions will streamline operations from ship to shore to distribution, allowing port operators to keep pace with increasing container traffic. Enabling these remote monitoring and automation applications ultimately improves the safety of employees by taking them out from under containers moving through the port.

Factory Case Study

» **Challenge:** manufacturers are constantly seeking ways to improve operations efficiencies and production capacity, but are faced with limited network solutions to enable heterogeneous device systems.

Factory Private LTE Market 2023 Opportunity

128.6 million shipments

$18.3 billion in Private LTE Addressable Smart Systems Revenue

» **Solution:** private LTE will enable key remote monitoring applications for a diverse equipment environment and support data services for mobile equipment and human machine interfaces (HMIs) allowing for greater visibility into system performance.

» **Impact:** bringing reliability, security, throughput and latency requirements to these business critical systems will improve overall system intelligence, enabling a broader set of devices and applications.

These case studies illustrate some of the ways private LTE can both support new applications as well as improve existing data services. If we take a hospital for example, day-to-day operations are highly business critical, where the cost of network downtime can translate to the well-being of patients. In this example, a dedicated LTE network can ensure low latency, high reliability and improved security for the communication of mobile equipment, patient data and practitioner logistics. For instance, visibility into the location of mobile equipment to support the operations around an incoming ICU patient can mean the difference between life or death.

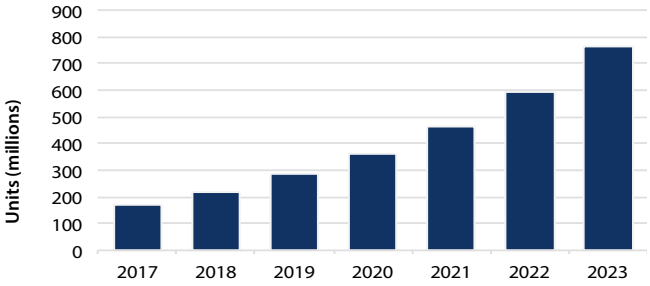
Furthermore, trials by member companies in the MulteFire and CBRS Alliances have proven that in instances of interference, the LTE-based technology achieves more consistent throughput than competitive technologies. This will bring reliable communications to an environment with dense infrastructure that can cause significant interference. Continuing the hospital example, the critical nature of patient data and the stringent HIPPA standards that are required in the communication of this data will be reinforced by another level of network security with a private LTE network using dedicated equipment. The closed nature of the network also allows the network manager to determine what data remains on site and what data is transmitted to the cloud, further driving the security of sensitive data.

These network characteristics will enable a simplified, flexible and unified approach to managing heterogeneous operational device networks across the identified industrial and business critical market environments. The combination of CBRS spectrum and MulteFire technology can allow for private LTE networks to scale and enable a new generation of applications for these market segments.

THE DOLLARS and DEVICES BEHIND THE PRIVATE LTE OPPORTUNITY

The global opportunity for private LTE in industrial and business critical environments will be significant, with an addressable market expected to exceed over 750 million device shipments by 2023 (Harbor Research). As a portion of the global opportunity, CBRS deployments in the United States are expected to drive stronger growth for this region. With this highly anticipated growth, industry players will move to capture and expand this value. The CBRS and MulteFire Alliances are focused on doing just that. With CBRS spectrum sharing architecture and

Exhibit 4: Private LTE Addressable Device Shipments, Worldwide, 2017-2023



Device shipments represent a piece of equipment enabled by a communication module equaling a new connection to the network.

MulteFire's expanded LTE capabilities, a network design bringing simplified deployment and LTE performance can address the current challenges around cost and performance that industrial and business critical IoT markets are facing today.

Within the addressable market for private LTE in industrial and business critical environments, we have forecasted four revenue categories associated with distinct technology segments:

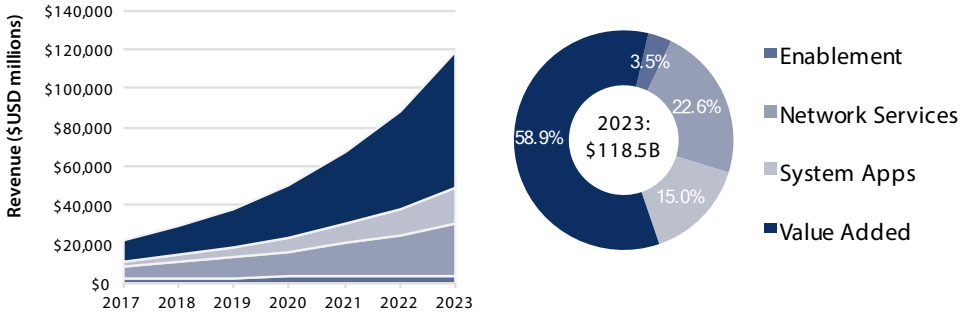
» Enablement: Wireline or wireless communications module for connectivity.

» Network Management: Ongoing provisioning, traffic management, configuration and general support of the network service.

» System Applications: Software platforms and services for provisioning, certification and integration of devices as well as device and data management functions. Applications include location and tracking, status and monitoring, upgrades and configuration, diagnostics and prognostics, and control and automation.

» Value Added Applications and Services: Smart Services also includes Value Added Application Services, including mobile and cloud services, database and analytics, asset management, energy management, supply chain, security and customer support.

Exhibit 5: Private IoT Addressable Smart Systems Revenue, Worldwide, 2017-2023



Source: Harbor Research 2017 Analysis

Market Segment Demographics (number of sites, global)

Transport Venues & Ports: *50,000*

Military Bases: *10,000*

Warehouses: *3,300,000*

Industrial & Manufacturing: *10,710,000*

Oil & Gas: *8,000*

Power Generation: *47,600*

Water Utility Plants: *140,000*

Mining: *54,000*

Hospitals & Labs: *263,000*

Total: *14,582,600*

Private LTE revenue opportunities exist across the entire technology stack, where much of the opportunity exists in industrial manufacturing, supply chain and energy industries:

» The total global Smart Systems revenue for the private LTE addressable market will grow from $22.1 billion in 2017 to $118.5 billion in 2023 at a 32.3% CAGR. The relative device shipment volumes will grow from 170.7 million in 2017 to 765.1 million in 2023 at a 28.4% CAGR.

» Total enablement revenues will grow from $1.8 billion in 2017 to $4.2 billion in 2023, representing a CAGR 14.5%. The more modest growth in device revenue is due to the expecting falling average selling prices for connectivity across all technologies. Private LTE chipsets are expected to follow the same general trend of increasing module commoditization.

» Network & Carrier Services revenues are projected to grow from $6.5 billion in 2017 to $26.8 billion in 2023. This represents a CAGR of 26.6%. This growth is largely due to the anticipated volumes of devices that will come online resulting in improved wireless networking technology.

» Revenues associated with System Applications, or middleware, are expected to increase from $3.1 billion in 2017 to $17.8 billion in 2020, representing an annualized growth rate of 33.9%. Much of this growth is due to application service providers and end users who are seeking easy means of managing devices.

» Total value-added service revenues have the potential to grow from $10.7 billion in 2017 to $69.7 billion in 2023 for a CAGR of 36.7%. These revenues represent the development of initial ancillary value-added data services with increasing support for complex applications.

These markets remain highly fragmented and competitive. Industrial and business critical customers are prudent adopters, driven by implementation costs and ROI. The benefits of IP-based networking have become very clear and this, combined with innovation around private LTE, will accelerate the uptake of wireless adoption. While progress has been made, there is still a need to improve interoperability among product solutions and their integration into the existing networks and systems.

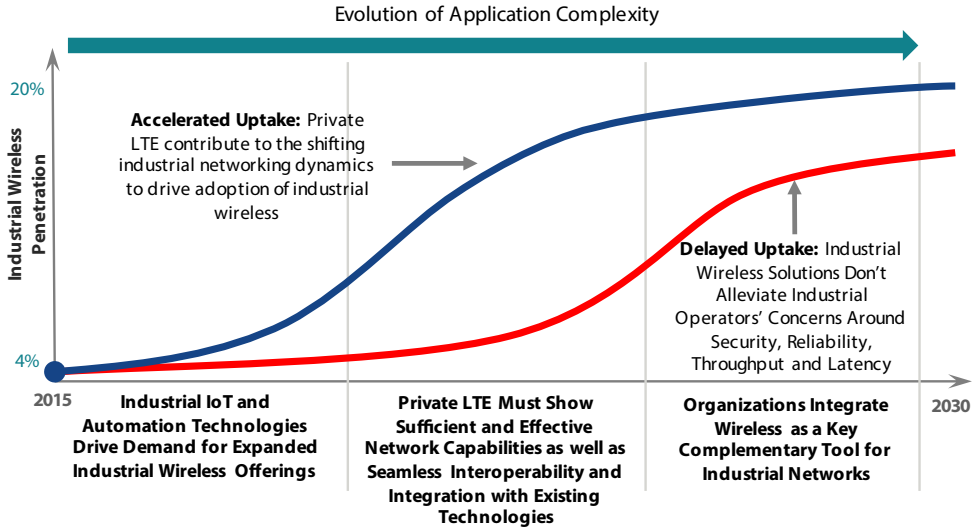
FUTURE VIEW FOR LTE with MULTEFIRE and CBRS TECHNOLOGIES

The current state of industrial and business critical environments point to an inflection point in networking technology evolution. The demand to connect more devices and leverage data-driven services is transforming the way OEMs, end users and technology suppliers interact. This will continually be hindered if wireless networks continue to isolate device groups in heterogeneous industrial

environments. The private LTE model introduces a potential remedy to the current fragmentation of the industrial wireless market.

This will be continually addressed as prospects of 5G will bring improved reliability and latency capabilities to the market. Those who develop the private LTE market will inherently drive the next steps towards 5G via investment in the distributed network infrastructure. The private LTE opportunity is here now and should be captured independently of the 5G timeline.

Exhibit 6: Opportunity to Accelerate the Adoption of Industrial Wireless Networks



The efforts of the CBRS and MulteFire Alliances represent the initial steps towards creating the collaborative ecosystem necessary to develop a new generation of industrial wireless networks. For example, the Nokia, Qualcomm and GE partnership around industrial deployments of private LTE will provide tangible evidence of the potential disruption private LTE will bring to the industrial wireless industry. In another instance of ecosystem innovation, Huawei has also effectively deployed private LTE solutions across shipping ports, mine sites and oil exploration platforms achieving better coverage, capacity and availability that improves the overall security, efficiency and sustainability of operations.

Strategic partnerships will enable the means for significant wireless penetration with the caveat that these networks will ultimately need to be interoperable and easily integrated into existing infrastructure. Private LTE network technology is setting the stage for a new chapter in smart connected wireless systems. The growth of wireless connectivity is not only inevitable, but it is necessary to engage in the next evolutionary step of Smart Systems. So the question should not focus on when or whether we will reach this next chapter, but rather who will engage in the collaborative efforts to turn the page.

ABOUT HARBOR RESEARCH

An internationally recognized research, technology, and business development consulting firm, Harbor Research has predicted, tracked, and driven the development of the Internet of Things since our inception in 1984. While our history is long, our strategy is simple: capture and create value by combining accurate data discovery and analysis with creative systems-thinking. It is this mindset that has given us the privilege of working with some of the greatest companies in the world. Today, we continue to work with C-level executives and top management of some of the world's most consistently successful companies and innovative startups. In the same way that the market has flexed and grown over the years, our services and experience have grown to make us the premier service organization you see today. We work with clients in a variety of ways including consulting, advisory, research and content development, thought leadership and workshop facilitation.

THOUGHT LEADERSHIP

We provide our clients with rigorous analysis and insight to support critical new business design and development decisions. Our research, content and modeling provides an ideal context for discovery, ideation and planning.

UNIQUE PROCESSES

As much as we would like to say there is a simple "linear" process to drive new smart systems innovation, the nature and complexity of the Internet of Things, there is no one best way to design an innovation process to design new systems.

VIBRANT COMMUNITY

Building new ventures for the Internet of Things requires new and very different modes of design and development – organizations will need to push the boundaries of collaboration to include many new and unfamiliar partici-pants.

If you or your colleagues would like to learn more:

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